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TESTS OF ARTIFICIAL FLIGHT AT HIGH ALTITUDES.

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If we wish to form an accurate idea of the extraordinary progress achieved in aeronautics, a comparison must be made of the latest altitude records and the figures regarded as the highest attainable limit some ten years ago. At that period, it was not possible to climb higher than a few hundred meters; nowadays, flight altitudes of 6000 to 8000 meters are no longer unusual, while altitudes of 9000 to 10000 meters and in one case of even 11000 meters have also been attained.

At these high altitudes, the air is so extremely rarefied (1/5 at 11000 m., for instance) that it no longer contains sufficient oxygen for the requirements of the human body, and recourse must therefore be had to artificial inhalation of oxygen.

It is desirable, for two reasons, that we should be able to define the limit of the altitudes that can be reached without this artificial aid. First of all, we must know to what precise extent the human body can endure the inhalation of rarefied air, lacking in oxygen, without transitory or permanent detriment to the health. Secondly, the mental capacity of the aviator must be tested at high altitudes and the limit known below which he is able to make reliable

observations without being artificially supplied with oxygen.

This task has been undertaken by Dr. KOSCHEL (M.D. and Ph. D.) in Berlin. At considerable risk to his own health, he is endeavoring to solve both problems and has made special investigations of the mental achievements of men remaining for any length of time in rarefied air.

Dr. KOSCHEL had previously carried out medical tests in a free balloon (up to an altitude of 9000 m.) and he has continued those tests of late years in an airship, in an airplane, under a parachute and finally in a pneumatic chamber. There is an advantage in the tests made in the pneumatic chamber through the absence of moral excitement, which is unavoidable under any other conditions; and alterations can also be easily made in the test conditions.

In the pneumatic chamber shown in the illustration, the requisite rarefaction of the air is effected by means of an air-pump. Up to the rarefaction equalling an altitude of 7500 m., Dr. KOSCHEL was assisted by several colleagues, all of whom, with the single exception of Army Dr. WULLENWEBER, inhaled oxygen from time to time from 7000 m., an observer requiring oxygen from 4500 m. upward.

By the time the rarefaction equalled that of an altitude of 8000 m., which is generally considered as the first stage of the danger zone for human life, Dr. KOSCHEL was the only remaining test subject.

Being anxious to preclude any shadow of doubt concerning the tests, Dr. KOSCHEL had himself shut up in the chamber without an oxygen-inhaler. He was then observed through the window shown in the illustration.

The following observations were imposed on the observer:

If the subject should become unconscious, an attempt must first be made to arouse him by knocking on the iron wall of the chamber. Should this fail to awaken him within half a minute to a minute, or if more serious symptoms - such as cramp - are evinced, aid must be rendered by gradual densification of the air, after a short observation has been made of the patient's condition.

During one test, Dr. KOSCHEL became profoundly unconscious three times at an altitude of 8000 m., besides having a bad attack of cramp.

The most important points gained from the tests, with regard to mental effort during a more or less prolonged stay at a high altitude, in rarefied air, may be summed up as follows:

Up to an altitude of 5500 m., no serious derangements were observed excepting a certain lassitude and disinclination for work. At 6000 m., the concentration of one of the men declined considerably, and the same effect was noticeable in the others to a less degree.

At 7000 m., the mental capacity of all the men deteriorated greatly in respect of test requirements. At 8000 m.,

Dr. KOSCHEL could work only for short periods, after which he became unconscious, and his achievements were very bad on all the points tested. Whenever the air was rarefied after temporary densification as a preventive measure against symptoms of mountain-sickness, the same low standard of mental power was evinced, and at a still lower altitude.

The capacity of the subject for concentration was thoroughly tested, the earliest symptoms of mountain-sickness being lassitude and consequent want of attention to the task in hand, which would obviate any high degree of mental activity such as the combination or association of ideas, etc.

Bourdon's system of blocking out letters was used in the tests of concentration and voluntary effort, the results of which could therefore be definitely stated in numerical terms. Capacity for concentration was moderate at 6000 m., and it deteriorated greatly at 7000 m. Measurements taken for this, as for other mental achievements, showed that all the men under test recovered in a similar way, - slowly in the case of increased air density, abruptly when oxygen was supplied for inhalation. It was further proved that a prophylactic oxygen inhalation of two minutes' duration at an altitude of 7000 m. would suffice to maintain the mental capacity of the men at a fair standard during the succeeding ten minutes. This experience was of great importance for the airships of the German Navy.

At an altitude of 7000 m., the men were still able to construct a sentence of three components, but none of them could number six components in succession according to the sense. This surprising result is probably due to the fact that only a quick glance and a rapid conception are needed for the construction of a sentence, while the enumeration of the six components demands the prolonged and repeated comparison and consideration of the single components. Even the copying of a row of eight figures or eight letters could not be correctly done by any one of the men at an altitude of 7000 m. Missing syllables were rapidly and correctly inserted in an unknown test by one of the men, at 4500 m.; at 6500 m., only 5/6 of the test was filled in, though with few mistakes, in the same length of time. Half the work only was done - and that very badly - at 7500 and 7000 m.; at 8000 m., only a few odd syllables were inserted, regardless of the sense of the text.

The capacity for written expression was particularly affected. Apart from the fact that the writing became worse and worse from 6500 m. onward, letters, words or portions of words were repeated and letters misplaced at 7000 m.; at 8000 m., senseless combinations of letters and syllables (agraphia) were noticeable.

Notes made by the men during the test, giving a continuous account of their personal sensations, etc., frequently showed signs of some predominating idea, which involuntarily

recurred and constantly reappeared in a whole series of sentences. The commencement of a fainting-fit, or of an attack of cramp, was evinced by sudden shakiness or interruptions in the writing.

Capacity for observation began to show derangement as low as some 6000 m., and it increased considerably at 6500 m. The capacity for recollecting events that had occurred before the test, and specially-acquired knowledge, was extremely low at 7000 m. After the test, slight recollection was shown of what had transpired at 6000 m., while there was still slighter recollection of events at higher altitudes, and even then, it could not be recalled later on without great difficulty.

An excited state of mind, similar to that produced by alcohol intoxication, was extremely marked at altitudes above 7000 m.

After a test lasting from one and a half to two hours, during which time Dr. KOSCHEL remained at 8000 m. several times and stayed one hour at 7000 m. without oxygen, he began to show symptoms of serious derangement of the passages, similar to those observed in patients at an advanced stage of dorsal disease, besides other symptoms. The derangement lasted about ten minutes, the other symptoms disappearing some hours later.

The rapidity with which Dr. KOSCHEL effected the transition from one altitude zone to another is most remarkable.

He was able to endure rarefaction up to 4000 m. within 3 minutes, to 5000 m. in 4 minutes, and to 6000 m. in 8 minutes without any inconvenience. He could also, on the other hand, endure densification from 7000 m. to ground level in 3 minutes, 30 seconds, (and densification from 5000 m. to ground level in 2 minutes in another test, which corresponds to a parachute velocity of 41 m. per second) though this could be done only after special training in the voluntary opening of the Eustachian tubes.

The aviator who has learned to adapt his respiration is capable of climbing to an altitude of about 6500 m. without much subjective inconvenience.

Subjective well-being is, however, no standard for the actual integrity of the mental capacity. This is one of the most important of the results obtained, and it was for his work on the subject that the degree of Ph.D. was conferred on Senior Army Doctor KOSCHEL.

If his observations are to be of any value, the aviator must therefore inhale oxygen at an altitude of 6000m. in flights of short duration, and at 5000 m. at latest in longer flights.